

IR CDS Status/Plans and IR Instrument Design

October 28, 2014

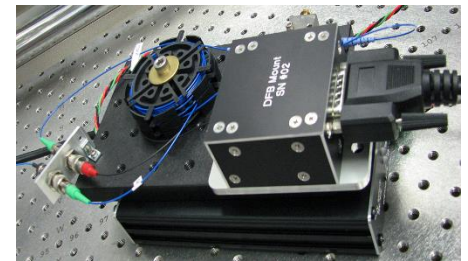
CLARREO SDT Meeting

Dave Johnson

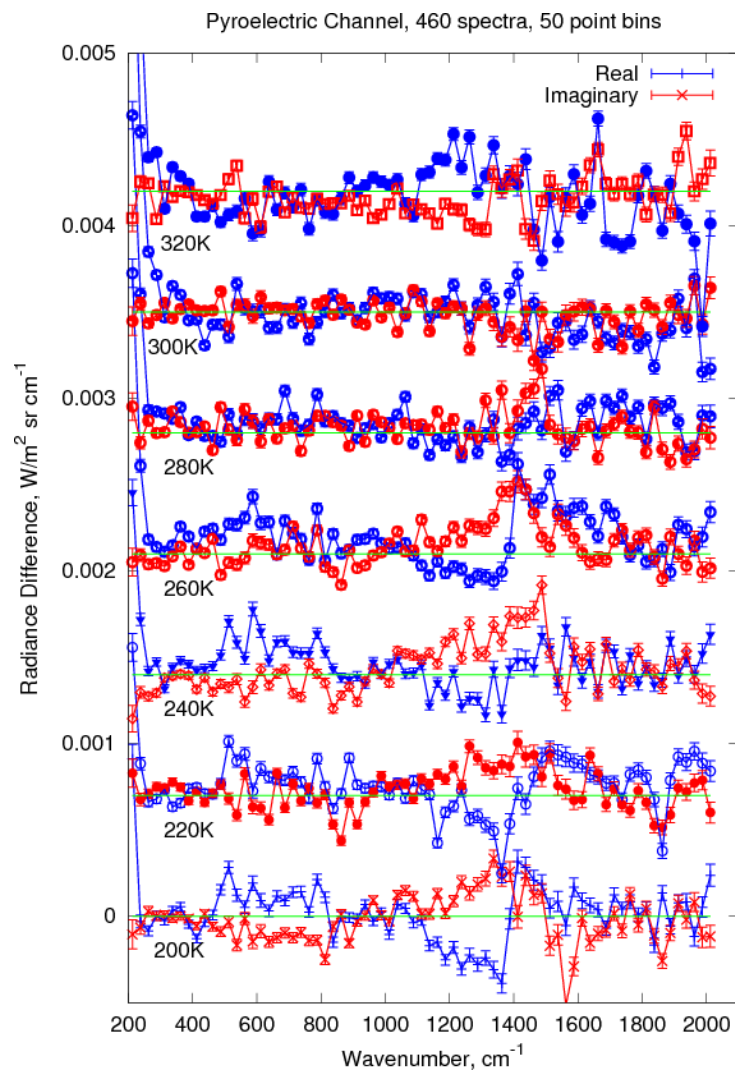
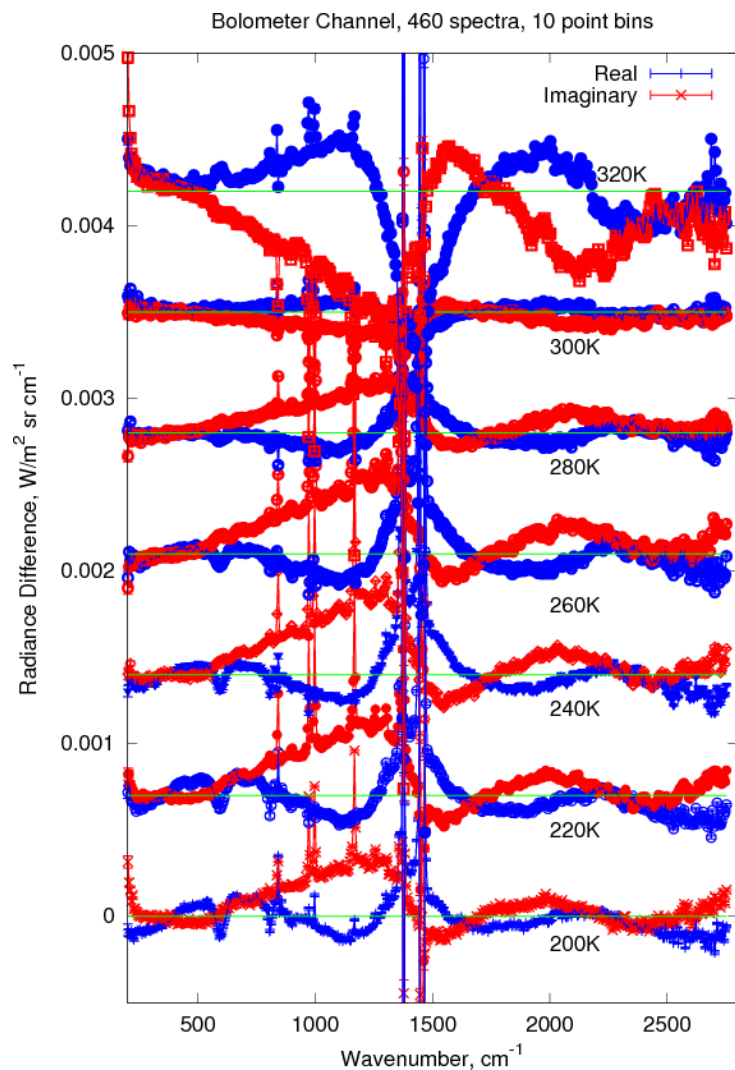
Rich Cageao

Infrared Calibration Demonstration System (CDS)

- Fabrication complete for HgCdTe detector channel; all parts received (July 2014).
 - Will determine flight-like detector radiometric accuracy from 1200-2000 cm^{-1} .
- Completed integration and testing of distributed feedback laser metrology system (July 2014).
 - Reduces mass and power of metrology system by 0.8 kg and 3.4W, respectively.

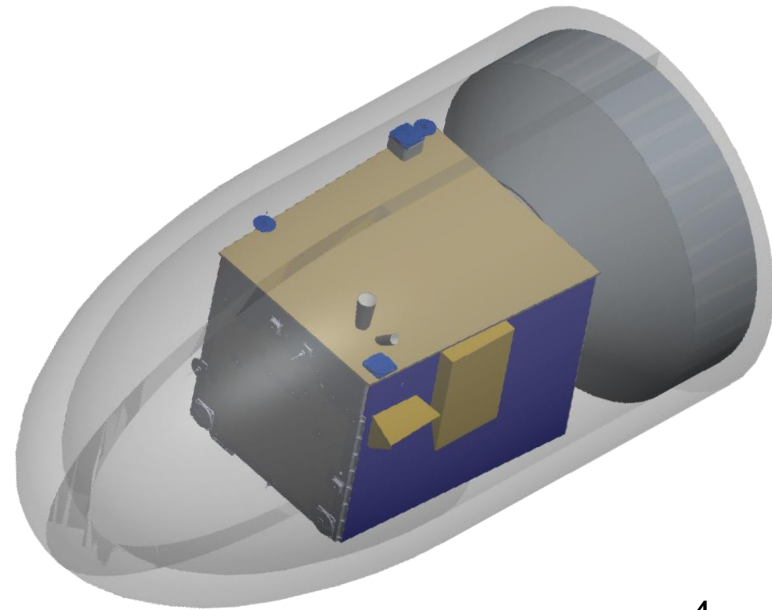


Current CDS Radiance Errors



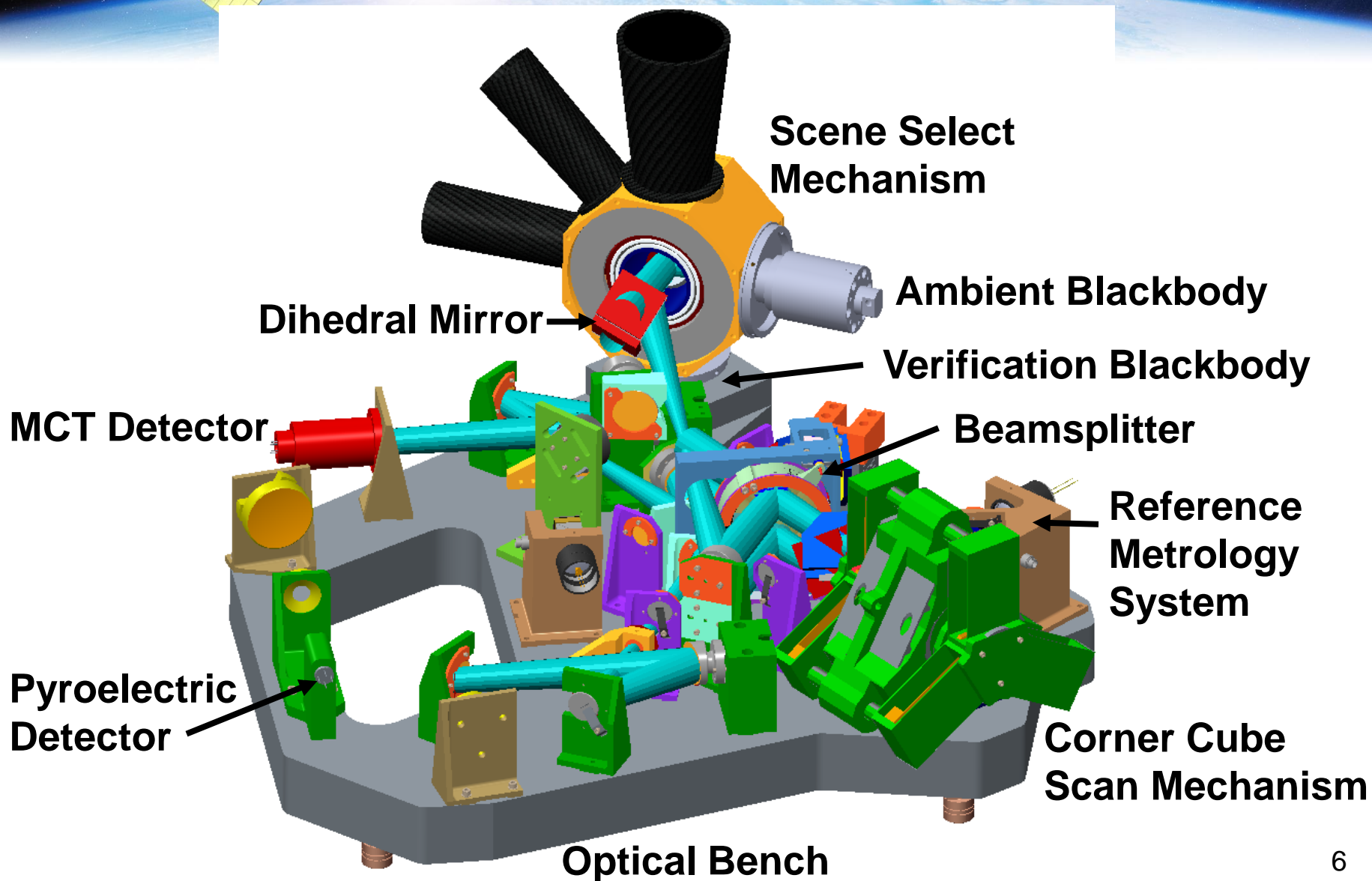
IR Instrument Redesign Goal and Assumptions

- **Design low cost mission that still produces useful science.**
- Use RSDO Catalog SSTL-150 spacecraft bus from Surrey Satellite Technology US, LLC.
 - Enables use of Pegasus L/V
 - S/C Bus is inexpensive, but provides limited resources:
 - 50 kg payload capacity.
 - 100 W payload power (peak.)
- IR instrument MCR design, for comparison:
 - 76 kg payload mass (CBE.)
 - 124 W average, 233 W peak power (CBE.)



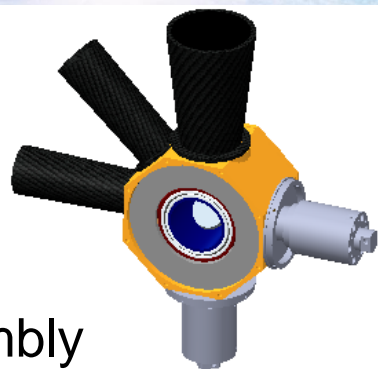
Instrument Design Change Summary

- Orbit: Sun-synch instead of polar.
- Packaging:
 - Rotate input polarization 45° and mount instrument flat to nadir deck.
 - Change SSM to cross-track and add in-track motion compensation.
 - Passively cooled BB & MCT detectors, no active control optical bench
- Calibration and verification system:
 - Eliminate QCL and integrating sphere used for ILS measurement and single-wavelength emissivity measurement.
 - Change 45° space view to 45° off-nadir view and get space view with spacecraft roll.
 - Operate verification BB at a single cold temperature only.
 - Passive cooling for MCT detectors



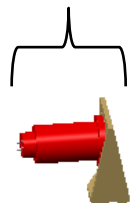
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Climate Absolute Radiance
& Refractivity Observatory



Scene Select

MCT Detector Assembly

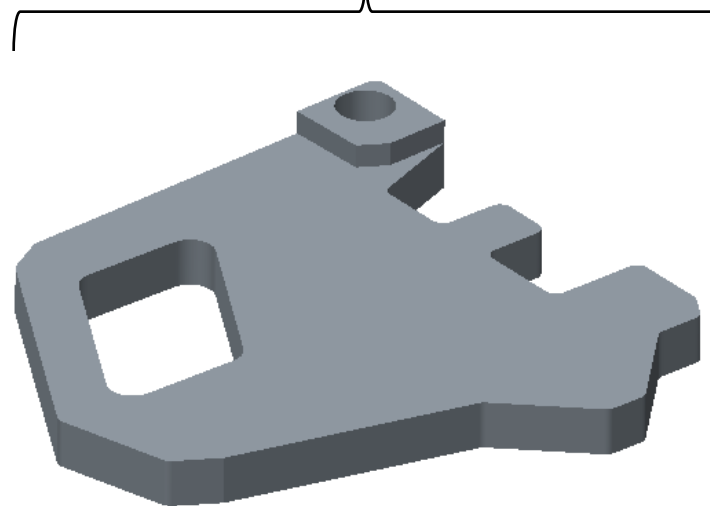


Pyroelectric
Detector Assembly



Main Instrument Assembly

Optic Bench

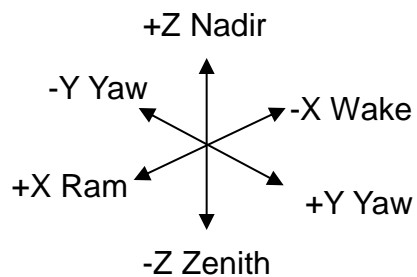
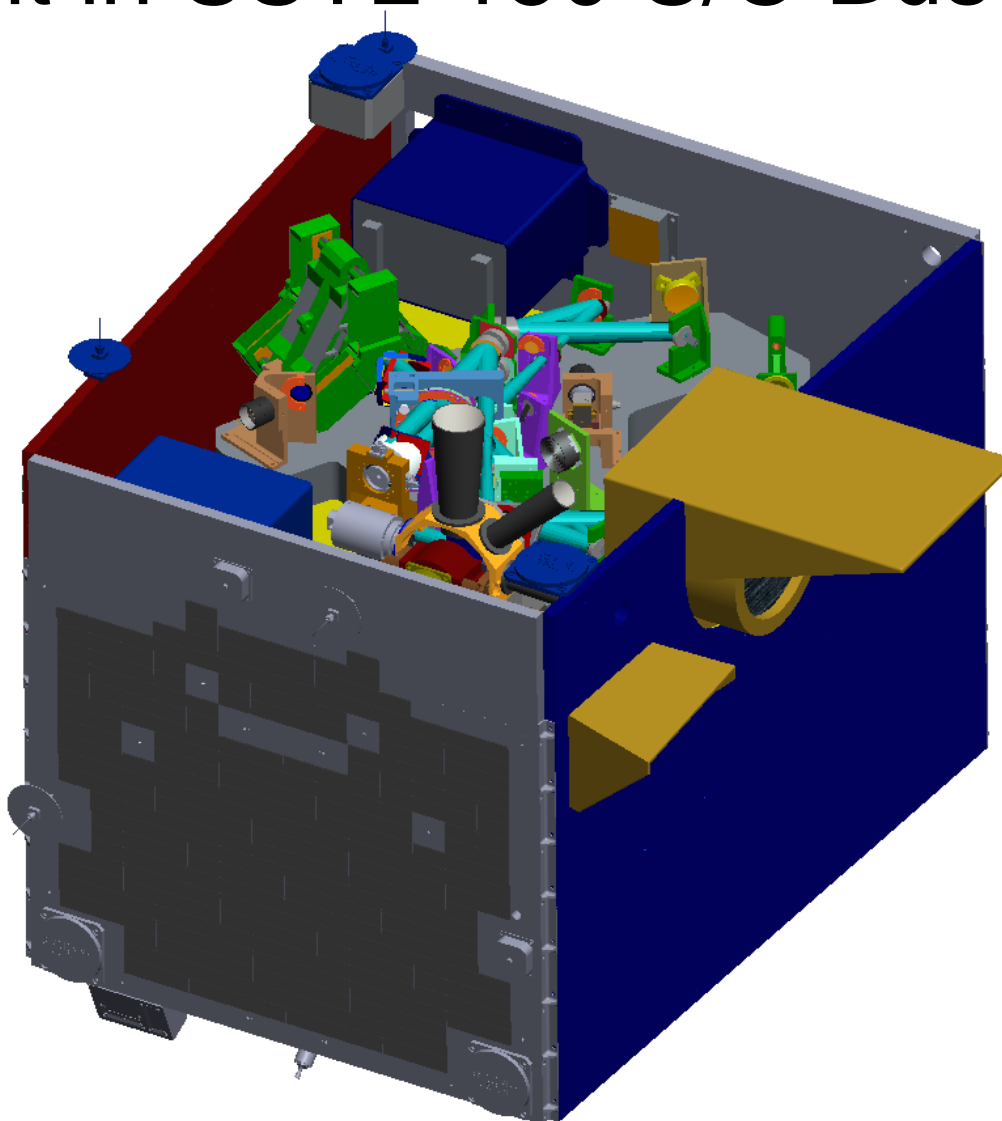


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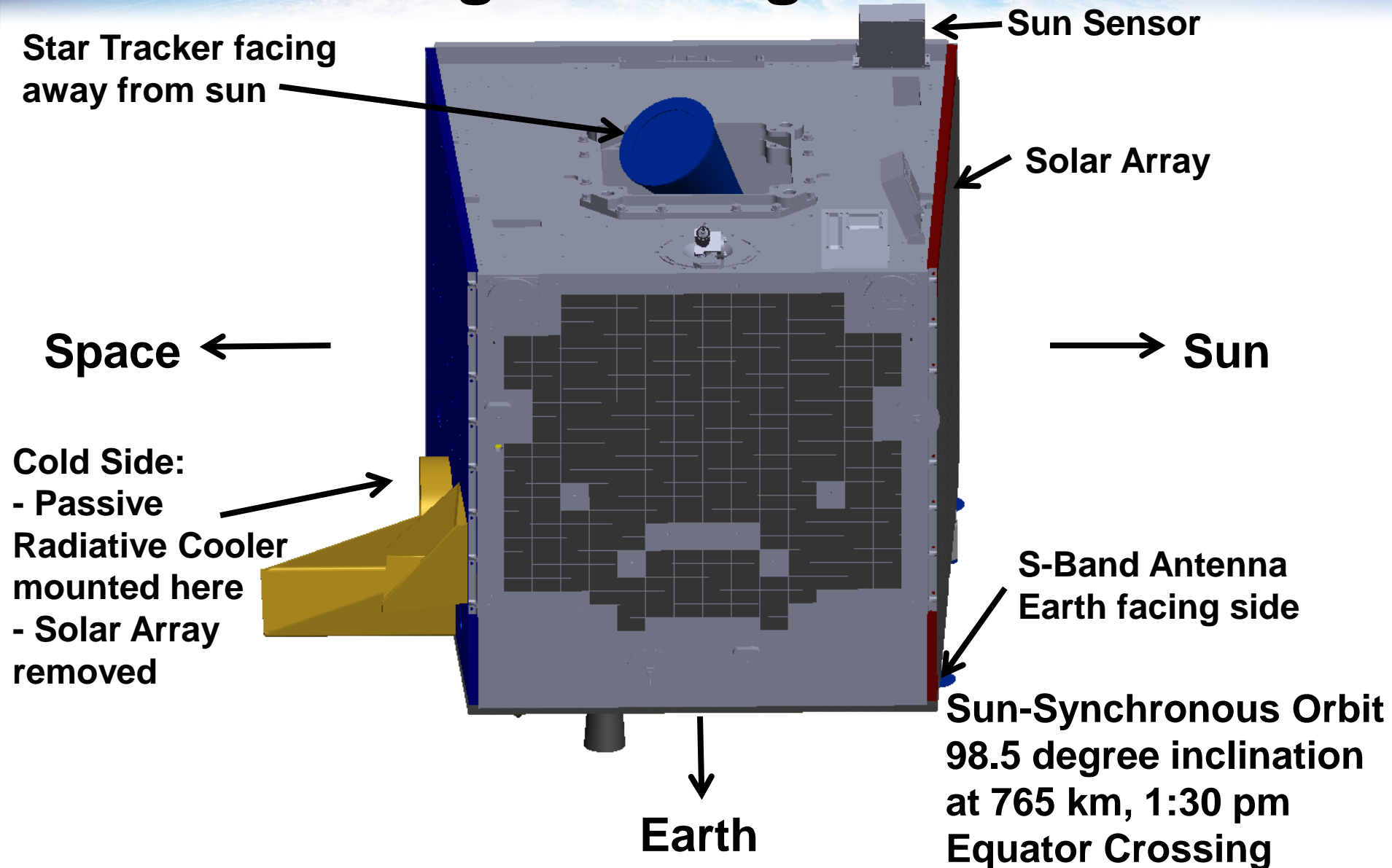


IR Instrument in SSTL-150 S/C Bus



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Flight Configuration



Orbit Change

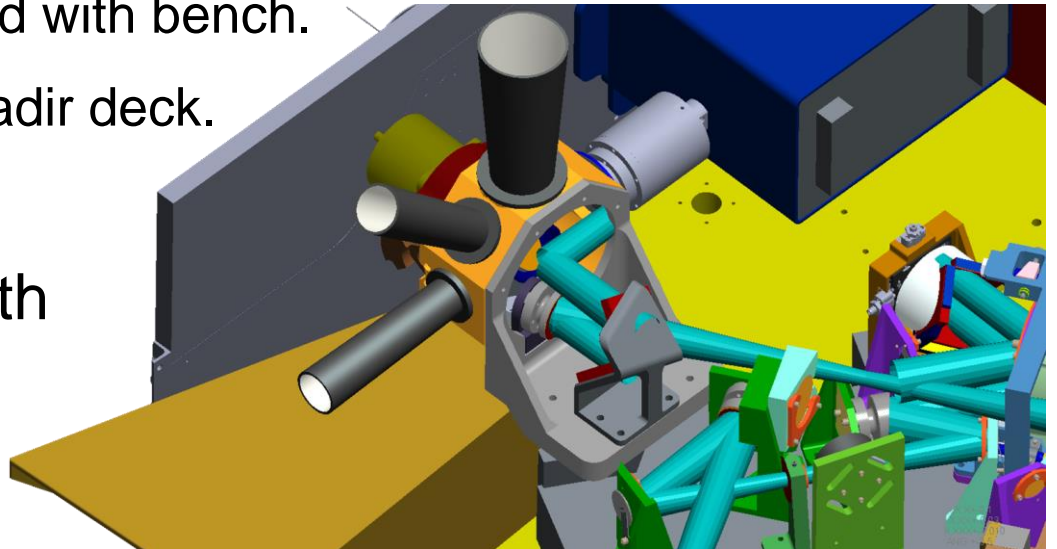
- MCR mission design based on true polar orbit.
- Switch to sun synch orbit.
- **Engineering benefits:**
 - Design simplified by having cold and solar illuminated sides.
 - Maximize available power without requiring solar panel gimbal.
 - Enable use of passive 80K cooler for MCT detectors, reducing cost, mass, and power requirements.
- **Science impact:**
 - Reduced intercalibration opportunities for most other satellites.
 - Lose diurnal coverage for benchmark and fingerprinting.

Other Orbit Change Benefits

- Enables passive thermal design
 - MCR design included active instrument temperature control.
 - New design will use passive thermal as demonstrated by CrIS:
 - CrIS is mounted on the nadir deck of a sun synch platform.
 - NPP CrIS is very stable.
- Intercalibration opportunities with other sounders:
 - JPSS (1:30 pm, 830 km) and AQUA (1:30 pm, 705 km) have extended overpasses every few days.
 - SNOs with other sun synch orbits occur at $\sim \pm 73.5^\circ$

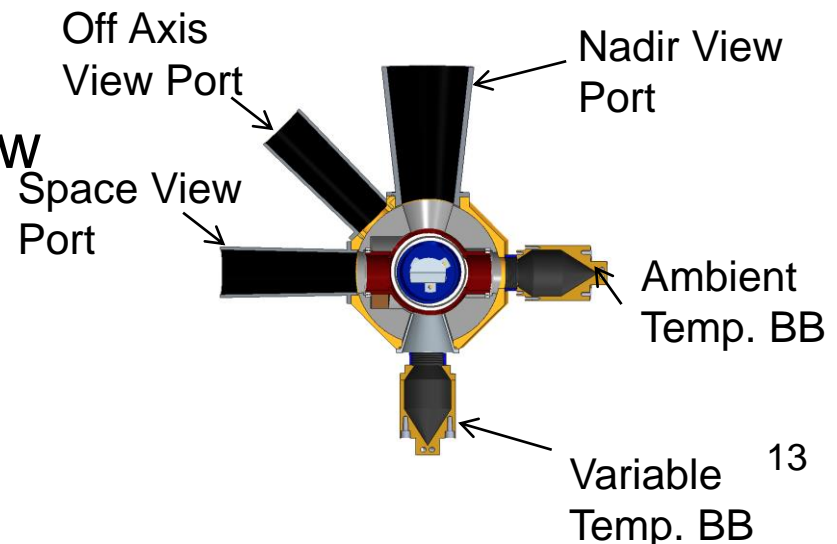
Input Polarization

- MCR concept had primary views at 45° relative to bench.
 - Eliminates polarization-induced calibration errors.
 - Instrument mounted 45° relative to nadir deck to get a nadir view.
- Introduce dihedral to rotate polarization 45°
 - Now primary views aligned with bench.
 - Instrument aligned with nadir deck.
- **Engineering benefit:**
Simplified package with reduced mass
- **Science impact:** None.



Alternate Space View

- MCR design included 45° off-zenith space view:
 - Used with zenith space view to quantify polarization errors.
- Switch to 45° off-nadir view:
 - Combine with spacecraft roll to get space view
- **Engineering benefit:** simplified packaging
- **Science/Engineering impact:**
 - Polarization measurement now requires spacecraft maneuver.



Scene Select Mechanism Change

- MCR design provides single axis scene select mechanism:
 - Selects nadir, calibration blackbody, space, and verification views.
 - Also provides earth scene motion compensation.
 - Rationale: single axis of motion believed to be simpler and cheaper.
- Redesign provides separate in-track motion compensation:
 - Large-range, low-accuracy cross-track scene select motion provided via stepper motor
 - Small-range high-accuracy in-track motion compensation provided via voice coil motor
 - Space view in cross track direction avoids ram, wake, and zenith.
- **Engineering benefit:** Simplified package at reduced mass.
- **Science impact:** None.

QCL and Integrating Sphere

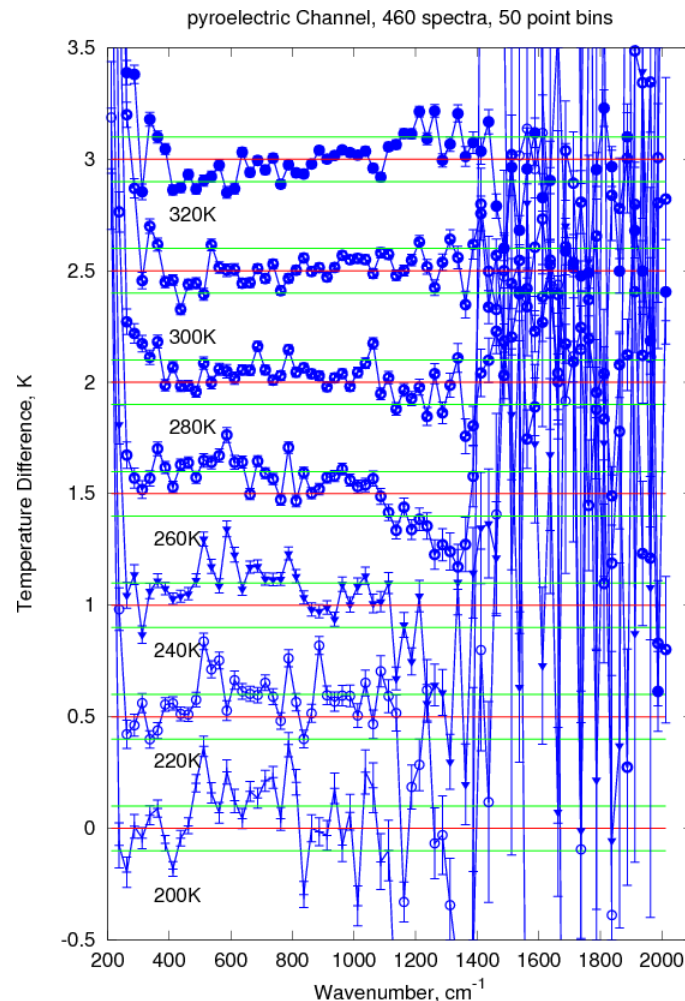
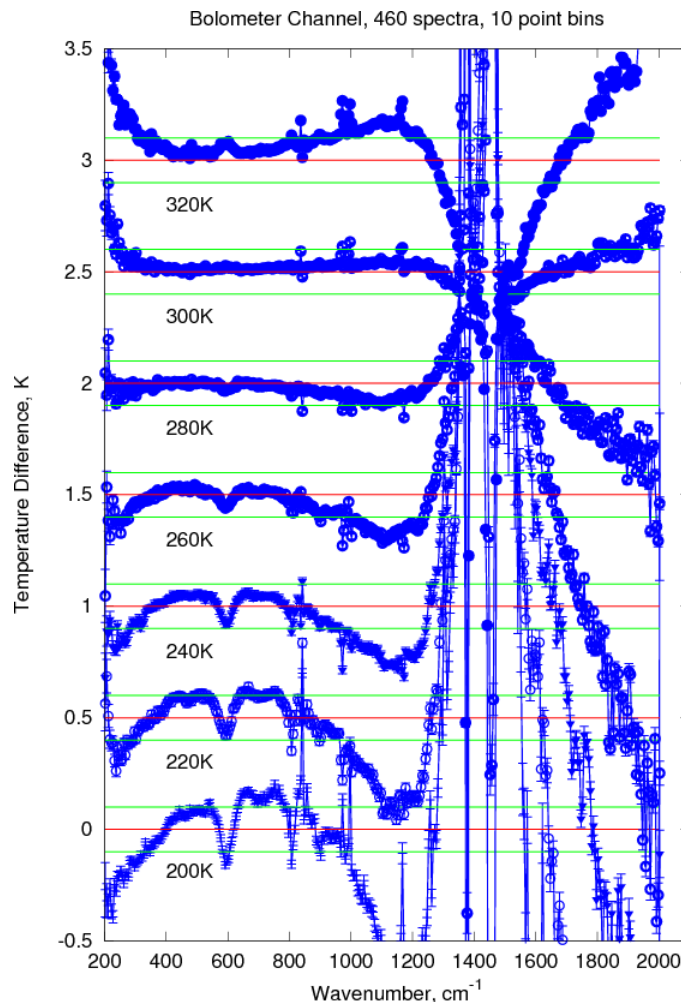
- MCR design includes quantum cascade laser, used for:
 - Single-wavelength blackbody reflectivity measurement.
 - Instrument line shape measurement (ILS; with integrating sphere.)
- New design removes QCL and integrating sphere.
- **Engineering benefit:** Reduced mass, power, & thermal load
- **Science impact:** Minimal
 - Heated halo provides spectral reflectivity measurement.
 - ILS (at multiple wavelengths) can still be derived from atmospheric spectra.

Verification Blackbody Temperature

- MCR verification blackbody (VBB) operates at multiple temperatures from 203K to 323K.
- Switch to single temperature VBB for nonlinearity check:
 - Add phase change cell (PCC) to calibration blackbody (CBB).
 - Errors approach zero for $T(\text{VBB}) = T(\text{CBB})$.
 - Errors on CDS increase systematically as $T(\text{VBB})$ decreases
- **Engineering benefits:** Reduced complexity and power
- **Science impact:** incomplete mapping of nonlinearity

Example of CDS errors

Calibration blackbody
temperature is
approximately 303K.
Errors increase toward
200K.

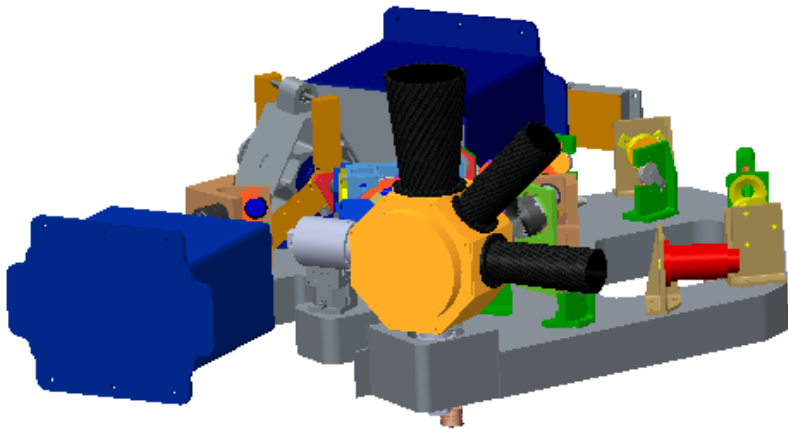


MCT Detector Passive Cooler

New thermal design for MCT detectors will use a passive radiator similar to SCISAT ACE:

- **Small focal plane, 80K temperature**
- **Radiator faces out on anti-sun side in sun synch orbit**

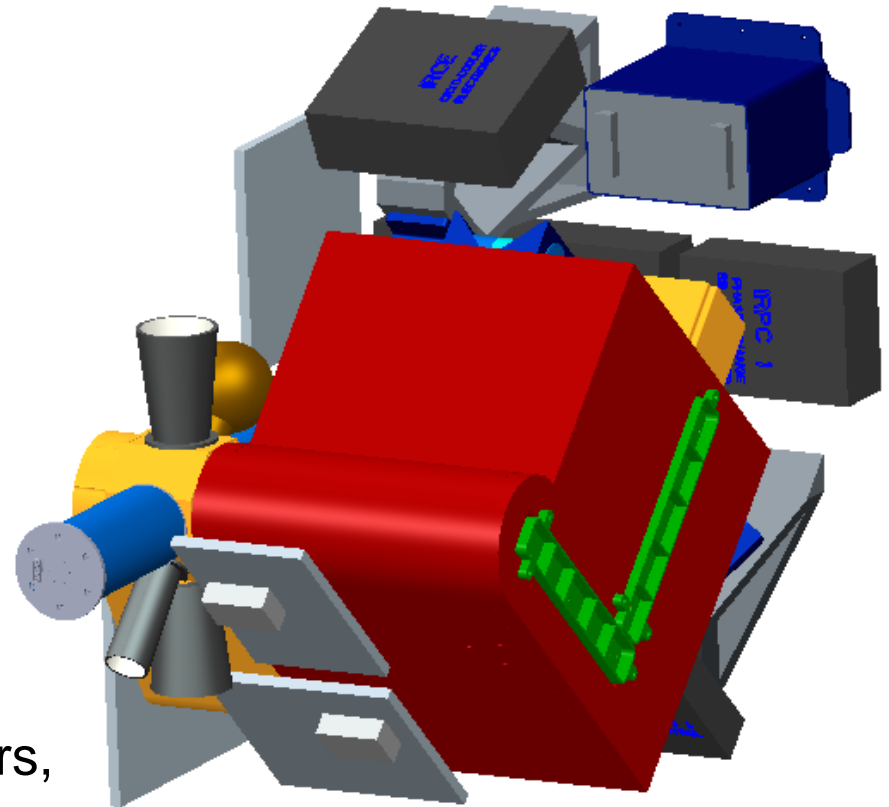
Summary of IR Design Changes



New design:

Mass: 44.8 kg (CBE, w/ cover, radiators, and cables)

Power: 75W ave, 102W peak

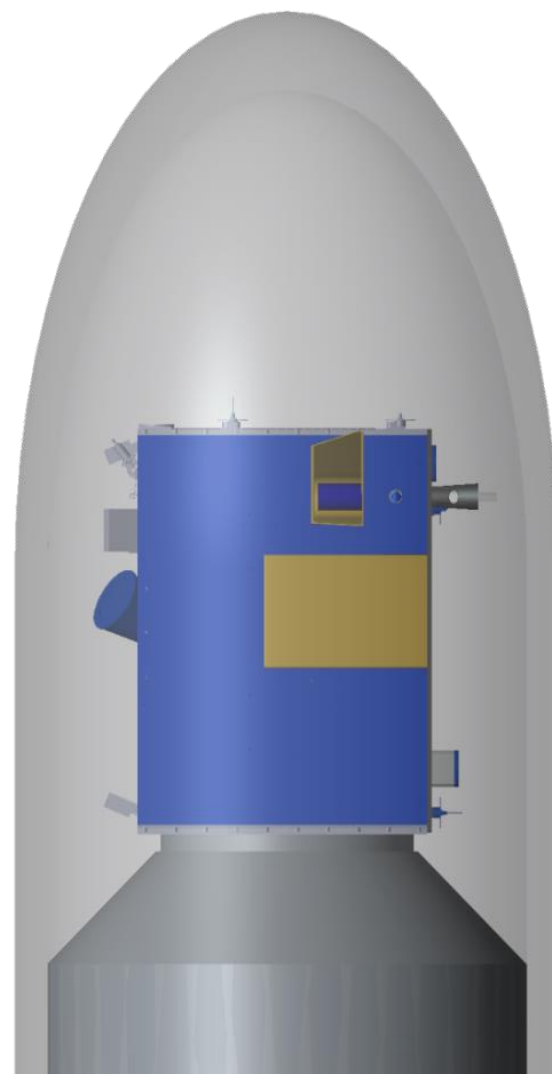
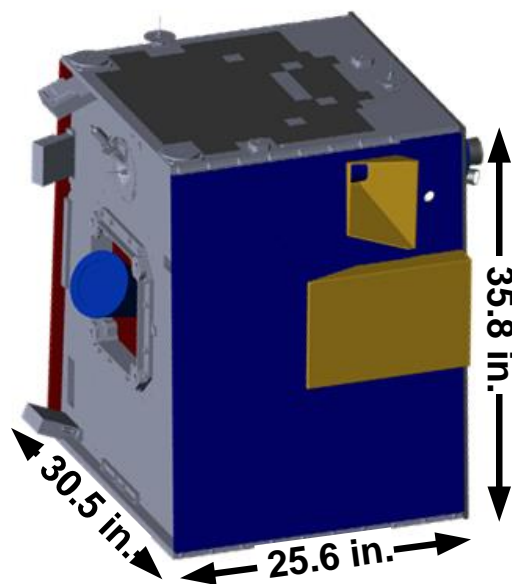


MCR design:

Mass: 76 kg

Power: 124W ave, 233W peak

Payload Integration



			IRON 130 LT Sunsynch Mission plus parallel RS 90 deg mission						
CLARREO Decadal Change Science Objective	Related Decadal Change Climate Variable	Science Impact Factor*	Reference Intercalibration & Spectral Fingerprint Capability	Calibration Verification Factor	Climate Record Length 70% Prob	1 IR FTS per S/C 1 S/C Trend Accuracy	1 Solar per S/C 1 S/C Trend Accuracy	1 GPS per S/C 1 S/C Trend Accuracy	Total Mission Science Value
Cloud Feedback SW	<i>Reflected SW flux, albedo</i>	2	1.00	1.5	2.3	0	1.05	0	7.2
	<i>Solar Cloud Properties</i>								
Cloud Feedback LW	<i>Earth Emitted LW flux</i>	1	1.00	1.0	2.3	1.03	0	0	2.3
	<i>IR cloud properties</i>								
Cloud Feedback Net	<i>Net Cloud Radiative Forcing</i>	5	1.00	1.3	2.3	1.03	1.05	0	15.0
Temperature Response & Lapse Rate Feedback	<i>Temperature Profile</i>	3	1.00	1.5	2.3	1.03	0	1	10.4
Water Vapor Response & Water Vapor Feedback	<i>Water Vapor Profile</i>	3	1.00	1.5	2.3	1.03	0	0.2	12.6
Aerosol Direct Radiative Forcing	<i>Aerosol Radiative Forcing</i>	1.5	1.00	1.5	2.3	0	1	0	5.1
	<i>Aerosol Properties</i>								
Snow & Ice Albedo Feedback	<i>Reflected SW flux, albedo</i>	1.5	1.00	1.5	2.3	0	1.05	0	5.4
	<i>Snow/Ice Cover, Cloud Cover</i>								
Land Albedo Change & Radiative Forcing	<i>Reflected SW flux, albedo</i>	0.5	1.00	2	2.3	0	1.05	0	2.4
Vegetation Index Change	<i>Vegetation Index</i>	1	1.00	2	2.3	0	1.05	0	4.8
Science Value of Individual Components (IR, RS, RO from COSMIC and other RO missions)						18.2	24.9	7.2	
Science Value of combined IR/RS science (net cloud feedback)						15.0			
Total Mission Science Value Metric									65.2
Percent of Mission Science Value of Individual Components (IR, RS, RO)						28%	38%	11%	
Percent of Mission Science Value of combined IR/RS science						23%			
Total Mission Science Value as Percent of CLARREO MCR Mission									85%